Cortically-inspired Computational Models for Multimodality

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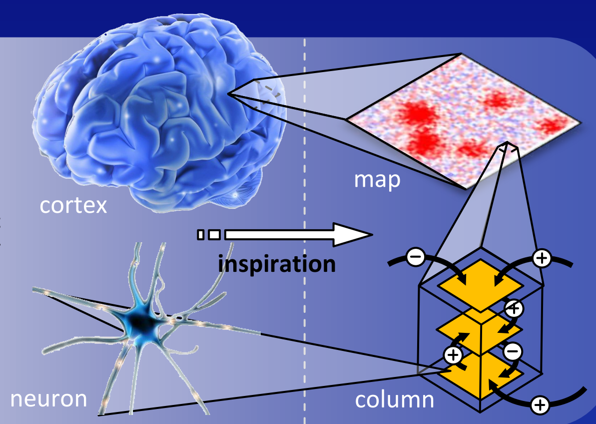
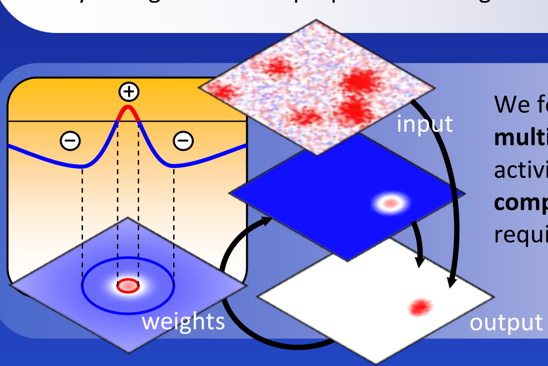
Dynamic Neural Fields

In the field of computational neuroscience, we develop **distributed models** of the cortex to account for perceptual and sensorimotor capabilities. Adopting a **mesoscopic level of modeling** with dynamic neural fields representing topologically organized populations of **cortical columns**, we propose various learning rules, competition mechanisms and interconnection schemes. Under the right conditions, these allow the **emergence of spatially coherent bumps** of activity yielding attentional properties and high robustness to noise.



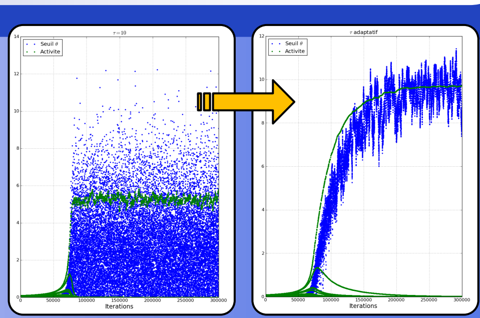


We focus in this poster on the **distributed, continuous and unsupervised learning of multi-sensory representations** and sensorimotor behaviors. For localized bumps of activity to emerge on cortical maps when coherent stimuli are presented, **adequate competition mechanisms** such as the CNFT (Continuous Neural Field Theory) are required. Nearby units can thus become selective to similar stimuli and self-organize.

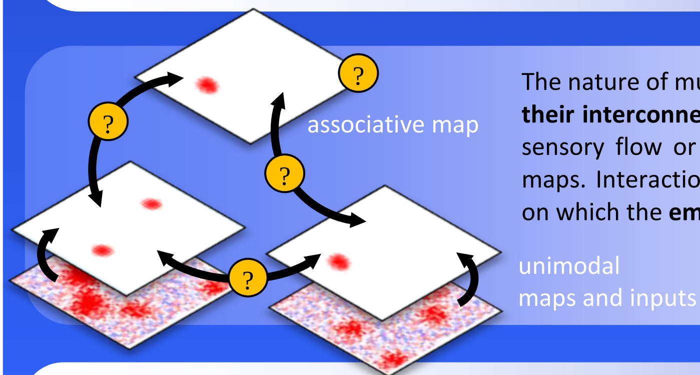
Competition & Self-organization

BCM Learning Rule

The BCM theory uses a **bio-plausible learning rule** for assemblies of neurons to become selective to specific stimuli. With the standard formulation of the rule, the lower the probability of a stimulus, the harder it is to become selective to it. This is problematic in a multimodal context, as it often leads to the dominance of one modality. **Adaptive parameters** are introduced **to improve stability and speed up convergence**.



$\tau = \tau_0$ $\qquad$ $\tau = \tau_0\,(\theta^2 + 1)$

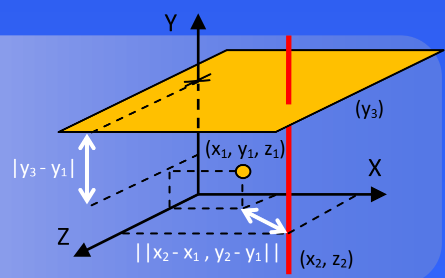


The nature of multimodal representations depends on the **number of maps used and their interconnections**. Different modalities can either be directly merged as a single sensory flow or directed to a set of unimodal maps later combined in associative maps. Interactions may directly **modulate the activity, dynamics or learning rules**, on which the **emergence of distributed coherent representations** depends.

Interconnection Schemes

Computational Abstraction

In order to **speed up the computations and alleviate the 2D constraints** of cortical sheets, the regular mesh generally considered can be replaced by **discrete interacting points**. The resulting topology lacks the flexibility of self-organizing maps but allows the manipulation of an **arbitrary and variable number of dimensions**.



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